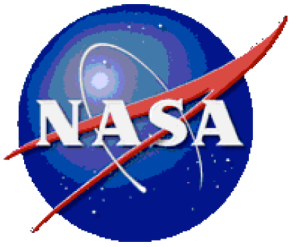

National Aeronautics and Space Administration
Advanced Planning & Integration Office
Technology Capability Roadmap

# Advanced Modeling, Simulation and Analysis

Erik Antonsson, NASA Chair
Tamas Gombosi, External Co-chair

Mayflower Hotel
Washington, DC
November 30, 2004

# Agenda

- Team Charter
- Importance to NASA
- Capability Breakdown Structure
- Roadmap Team steps
- Status
- Summary of White Papers
- Agenda

# Modeling & Simulation Team Co-Chairs

Erik K. Antonsson, Ph.D., P.E., Chief Technologist, Jet Propulsion Laboratory; Professor of Mechanical Engineering, California Institute of Technology.

Research focus: Engineering System Design Methods

Tamas Gombosi, Ph.D., Professor and Chair in the Department of Atmospheric, Oceanic and Space Sciences; Professor of Aerospace Engineering; Director of the Space Physics Research Laboratory at the University of Michigan and Director of the Center for Space Environment Modeling.

Research focus: Development of a first-principles based, predictive global space weather simulation framework (SWMF) extending from the solar photosphere to the terrestrial atmosphere; High-performance multiscale 3D MHD simulations of solar system plasmas on solution adaptive unstructured grids.

# Modeling & Simulation Team
# NASA SMD Representatives

Harley Thronson, Ph.D., Assistant Associate Administrator, Technology, Science Mission Directorate (SMD).

His previous duties at NASA have included serving as the Acting Science Program Director for the Astronomical Search for Origins and Planetary Systems. He has also served as the senior scientist for the Hubble Space Telescope (HST), the Spitzer Space Telescope (SIRTF), and the James Webb Space Telescope (JWST). Over the past few years, he has served as senior scientist for the Decade Planning Team, the NASA Exploration Team, and a number of other long-range planning activities.

Giulio Varsi, Ph.D., Deputy Assistant Associate Administrator, Technology, Science Mission Directorate (SMD).

# Modeling & Simulation Team
# NASA APIO Coordinator

Janice Aikins, Ph.D., Advanced Planning and Integration Office (APIO).

Dr. Aikins previously held the position of Director, Global Engineering for Sun Microsystems. While at Sun, Dr. Aikins also held the position of Director, Technology Planning and Communications.

As Director of Technology Integration for Adobe Systems, Dr. Aikins defined cross-product, corporate solutions for shared product technologies and use of shared resources.

Dr. Aikins served as Principal, Corporate Strategy and Innovation, at Xerox PARC, and was a founder of a startup, Aion Corporation, now a part of Computer Associates.

# Modeling & Simulation Team Charter

To identify what is needed to enhance NASA's capabilities to produce leading-edge exploration and science missions by improving engineering system development and science understanding through broad application of advanced modeling, simulation and analysis techniques.

# Modeling & Simulation Definition

Engineering Systems:

Develop applications for engineering to enable prediction of performance of many alternatives, to rapidly and systematically explore complex design spaces, and to evaluate designs where testing is not possible.

Science Data Analysis & Science Scenarios Execution:

Develop and implement applications in multiple science disciplines to understand elucidate physical phenomena, and to analyze experimental results.

Identify necessary infrastructure to enable those applications to be run effectively.

# Importance to NASA

- Modeling and simulation are being used effectively throughout the Space business
  - Engineering
  - Science
- These tools allow high fidelity simulations of systems
  - Simulating environments that are difficult or impossible to create on Earth
  - Rapid exploration of complex engineering design trade spaces
  - Removing humans from experiments in dangerous situations
  - Providing visualizations of datasets that are extremely large and complicated.
- Examples of past simulation successes
  - Hypersonic flowfield simulations around the Space Shuttle Columbia
  - Coupled optical/thermal/structural simulations of telescope systems
  - Simulations of entry conditions for man-rated space flight vehicles
  - Visualizations of distant planet topography via simulated fly-over
  - 3-D visualizations of coupled ocean and weather systems.

Note: In many of these situations, assimilation of real data into a highly sophisticated physics models is needed

# Topic Content - Level 1

- Computing Software Systems and Tools
- Systems Management Technology
- Applications
- Networking

# Topic Content

**Computing Software Systems and Tools**

- **Operating Systems**
  - **Usability and scalability**
  - **System reliability**
- **Languages, Compilers, and Libraries**
  - **New, tailored languages**
  - **Automated compiler optimization**
- **Software tools and Development environments**
  - **Distributed**
  - **Cluster**
  - **Grid computing**
- **Algorithms**
  - **High performance on multiprocessor systems**
  - **Libraries**
- **Frameworks**
  - **Solid Earth**
  - **Earth Science Modeling Framework**
  - **Space Weather Modeling Framework**
- **Data Management and Transport**
  - **High speed cache management systems**
  - **Intelligent data controllers**
- **Human/ computer interfaces**
  - **Application-specific GUIs**
  - **Portal management tools**
  - **Resource management tools**
- **Collaborative environments**
  - **Software systems**
  - **Shared applications**
- **Visualization tools**
  - **Display technologies**
- **High speed read-in/read-out**

# Topic Content

## Systems Management Technology

- **Systems architecture**
  - **Systems designs for science and engineering**
  - **Multi-user optimization**
  - **Simulation Environments**
- **System modeling and performance analysis**
  - **Tools to assess code/machine interactions**
  - **Optimization approaches for systems**
- **Reliability, availability, serviceabiliyt, and security**
  - **Fault isolation / fail soft**
  - **Defense against malicious intent**
- **Programming models**
  - **New, abstract constructs**
  - **Consistency with legacy code**

# Topic Content

**Applications**

- Science Discovery and Analysis
  - Earth System Simulation
  - Space Physics
  - Astrophysics
  - Planetary Science
  - Fluid Dynamics
- Mission Engineering and Design Tradespaces
  - Mission Design
  - Spacecraft Design
  - Instrument Design
  - Space Environment Interactions
- Data assimilation approaches
  - Simulation systems
  - Data access systems
- Outreach Applications

# Topic Content

**Networking**

- **Long haul, Ultra-high bandwidth**
  - **Infrastructure**
  - **Distributed, dynamic resource allocation**
- **Protocols**
  - **High efficiency transmission**
  - **Reliable transmission**
- **Data access / virtual storage tools**
  - **Virtual, verified, secure access to distributed data sets**
  - **Metadata management**
  - **Service brokers**

# Related Roadmap Teams

- Systems Engineering Cost/Risk Analysis
- Advanced Telescopes and Observatories
- Scientific Instruments/Sensors
- Robotic Access to Planetary Surfaces
- High-Energy Power and Propulsion

# Modeling & Simulation Team Process

Starting from a set of Design Reference Missions and Measurements

Identify Enabling Capabilities

Assess Required Technologies

- Identify relevant technologies
- Assess the state-of-the-art capability
- Derive requirements

Develop Roadmap (timing/phasing, maturity, etc.)

- Identify the performance level needed by the reference missions/measurements and trace the development required.

# Roadmap Steps

- Form team
- Finalize the topic content
- Solicit input from broad community on capabilities needed
- Team meeting #1
  - Review and assess charter, topic and input
  - Assign areas of planning to subteams
  - Produce subteam plans
- Team meeting #2
  - Review and assess all subteam inputs
  - Produce draft roadmap
- Team meeting #3
  - Review draft roadmap

# Status

- Team is selected
- Preliminary topic content and structure exists
- First telecon meeting planned for first week of December
- First team meeting planned for first week of January

# Summary Statistics of White Papers

- Total of 31 papers
- Total of 17 registrants with M&S papers
- Breakout by subject:
  - 7 in Aerospace systems design
  - 6 in Vendor capabilities
  - 1 in Health Management systems
  - 1 in Navigation modeling
  - 1 in large scale distributed computing
  - 1 in large scale computing for science models

| Advanced Modeling, Simulation & Analysis Public Meeting Agenda | | | |
|---|---|---|---|
| **Author** | **Organization** | **Title** | **Schedule** |
| William Campbell | NASA GSFC | Virtual Immersion into Data | 11:00 |
| George Davis | Emergent Space Technologies | Distributed Space Systems | 11:15 |
| Mark Gersh | Lockheed Martin | Goals and Challenges | 11:30 |
| Cindy Kurt | United Space Alliance | Mission Design | 13:00 |
| Jason Lohn | NASA ARC | Automated Design Systems | 13:15 |
| Doug VanGilder | AFRL, VPI, UCLA, JPL | Experimentally Validated Simulation | 13:30 |
| Michael Williams | Savannah River National Laboratory | SRNL Capabilities | 14:00 |
| Martin Lo | NASA JPL | New Trajectories | 14:15 |
| Aaron Johns | UGS | UGS/Team Center Capabilities | 14:45 |
| Dave Smith | Boeing | Coupled Science Models | 15:00 |
| Charles Norton | NASA JPL/GSFC | Parallel Meshing | 15:15 |
| Sanjay Garg | NASA GRC | Health Management Systems | 15:30 |
| Trygve Magelssen | Futron Corporation | Technology Infusion Assessment System | 15:45 |